

CLAIMS

We claim:

- 5 1. A computer implemented method for predicting failure in a system, comprising:
measuring data associated with a system;
creating a prediction of a failure of said system using a probabilistic model
and said data; and
communicating said prediction.
- 10 2. The method of claim 1 wherein said measuring further comprises receiving system
information from said system.
3. The method of claim 1, wherein said creating further comprises creating a prediction
15 of a failure of a component of said system.
4. The method of claim 1, wherein said creating further comprises creating a prediction
of a failure of multiple systems based on said prediction.
- 20 5. The method of claim 1 wherein said measuring, creating, and communicating steps
are performed on said system.
6. The method of claim 1 further comprising comparing said prediction to criteria. .
- 25 7. The method of claim 1 wherein at least one of said creating and communicating
steps occurs at a remote location.
8. The method of claim 1 wherein said probabilistic model comprises multiple models.
- 30 9. The method of claim 1 further comprising ranking variables in said probabilistic
model according to said variable's contribution to said prediction.
10. The method of claim 1 applied to predict failure in a material's microstructure.

11. The method of claim 1 wherein said data comprises referenced data, sensed data,
5 and inferred data and wherein said method further comprises relating said reference data to
a first set of variables, relating said sensed data to a second set of variables, and inferring a
third set of variables from said sensed data.
12. The method of claim 1 further comprising sending said data to a remote location
10 and wherein said creating occurs at said remote location.
13. The method of claim 12 further comprising receiving said prediction from said
remote location.
14. The method of claim 1 further comprising developing said probabilistic model prior
15 to said creating.
15. The method of claim 14 wherein said developing further comprises:
identifying at least one failure mechanism of a component of said system
20 from said component's characteristics selected from a group comprising: material
properties, environmental conditions, design characteristics, component loading, and
component usage;
identifying significant random variables of said at least one failure
mechanism;
25 identifying statistical parameters of said significant random variables; and
formulating a strategy for probabilistic analysis.
16. The method of claim 15 wherein said data comprises referenced data, sensed data,
and inferred data and wherein said developing step further comprises determining which of
30 said significant random variables are related to said referenced data, which of said
significant random variables are related to said sensed data, and which of said significant
random variables are inferred from said sensed data.

17. The method of claim 12 wherein said developing further comprises setting criteria for communicating said prediction.
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18. The method of claim 1, wherein said probabilistic model utilizes fast probability methods.
19. The method of claim 18, wherein said fast probability methods are selected from a group including direct: First Order Reliability Methods, Second Order Reliability Methods, Advanced Mean Value methods, and Mean Value methods.
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20. The method of claim 18, wherein said fast probability methods are selected from a group including response surface: First Order Reliability Methods, Second Order Reliability Methods, Advanced Mean Value methods, and Mean Value methods.
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21. The method of claim 1, wherein said probabilistic model utilizes simulation techniques.
22. The method of claim 21, wherein said simulation techniques are direct methods selected from a group including: Monte Carlo methods and importance sampling methods.
23. The method of claim 21, wherein said simulation techniques are response surface methods selected from a group including: Monte Carlo methods and importance sampling methods.
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24. The method of claim 15, wherein at least one said failure mechanism is described by an equation and said equation is divided into a capacity section and a demand section.
25. An apparatus for predicting failure of a system, said apparatus comprising:
sensors for acquiring data from a system;
a first computer comprising:
a processor;
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a memory containing:

instructions for measuring said data;

5 instructions for creating a prediction of a failure of said system using
a probabilistic model and said data; and

instructions for communicating said prediction; and

a communication device for communicating said prediction.

10 26. The apparatus of claim 25 wherein said instructions for creating further comprise
instructions for predicting failure of at least one component of said system.

27. The apparatus of claim 25 wherein said instructions for measuring further comprise
instructions for receiving system information from said system.

15 28. The apparatus of claim 27 further comprising a second computer, said second
computer comprising:

a processor; and

a memory, said memory containing:

20 instructions for measuring said data;

instructions for storing said data;

instructions for sending said data to said first computer as said system
information.

25 29. The apparatus of claim 25 further comprising:
a second computer, said second computer comprising:

a processor; and

a memory, said memory containing:

instructions for receiving said prediction; and

30 instructions for communicating said prediction; and
a second communication device for communicating said prediction.

30. The apparatus of claim 25 wherein said communication device further comprises a warning signal.

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31. The apparatus of claim 25, said apparatus further comprising a sending device for sending said data to a remote location.

32. The apparatus of claim 31, wherein said first computer is located at said remote location.

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33. The apparatus of claim 25 further comprising instructions for comparing said prediction to criteria.

34. The apparatus of claim 25 wherein said probabilistic model comprises multiple models.

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35. The apparatus of claim 25 wherein said probabilistic model comprises variables ranked according to said variables' contribution to said prediction.

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36. The apparatus of claim 25 applied to predict failure in a material's microstructure.

37. The apparatus of claim 25 wherein said data comprises referenced data, sensed data, and inferred data and wherein said apparatus further comprises instructions for: relating said reference data to a first set of variables; relating said sensed data to a second set of variables; and inferring a third set of variables from said sensed data.

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38. The apparatus of claim 25, wherein said probabilistic model utilizes fast probability methods.

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39. The apparatus of claim 38, wherein said fast probability methods are selected from a group including direct: First Order Reliability Methods, Second Order Reliability Methods, Advanced Mean Value methods, and Mean Value methods.

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40. The apparatus of claim 38, wherein said fast probability methods are selected from a group including response surface: First Order Reliability Methods, Second Order Reliability
5 Methods, Advanced Mean Value methods, and Mean Value methods.

41. The apparatus of claim 25, wherein said probabilistic model utilizes simulation techniques.

10 42. The apparatus of claim 41, wherein said simulation techniques are direct methods selected from a group including: Monte Carlo methods, and importance sampling methods.

43. The apparatus of claim 41, wherein said simulation techniques are response surface methods selected from a group including: Monte Carlo methods, and importance sampling
15 methods.

44. The apparatus of claim 25 wherein said instructions for creating further comprise instructions for creating a prediction of a failure of multiple systems based on said prediction.
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45. The apparatus of claim 25, said probabilistic model comprising at least one failure mechanism of a component of said system.

46. The apparatus of claim 25, wherein said at least one failure mechanism relates to a
25 material microstructure.

47. The apparatus of claim 25, wherein said at least one failure mechanism is described by an equation and said equation is divided into a capacity section and a demand section.

30 48. A computer program product for predicting failure of a system for use in conjunction with a computer system, said computer program product comprising a computer readable storage medium and a computer program mechanism embedded therein, said computer program mechanism containing:

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instructions for measuring data;
instructions for storing said data;
5 instructions for creating a prediction of failure of said system using a
probabilistic model and said data; and
instructions for communicating said prediction.

49. The computer program product of claim 48 wherein said instructions for measuring
10 data further comprise instructions for receiving system information from said system.

50. The computer program product of claim 48 wherein said instructions for creating
further comprise instructions for creating a prediction of a failure of at least one component
of said system.

15 51. The computer program product of claim 48 wherein said instructions for creating
further comprise instructions for creating a prediction of a failure of multiple systems based
on said prediction.

20 52. The computer program product of claim 48, said model comprising at least one
failure mechanism of a component of said system.

53. The computer program product of claim 48, wherein said at least one failure
mechanism relates to a material microstructure.

25 54. The computer program product of claim 48, wherein said at least one failure
mechanism is described by an equation and said equation is divided into a capacity section
and a demand section.

30 55. The computer program product of claim 48 further comprising instructions for
comparing said prediction to criteria.

56. The computer program product of claim 48 wherein said probabilistic model
comprises multiple models.

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57. The computer program product of claim 48 further comprising ranking variables in
5 said probabilistic model according to said variables' contribution to said prediction.

58. The computer program product of claim 48 applied to predict failure in a material's
microstructure.

10 59. The computer program product of claim 48 wherein said data comprises referenced
data, sensed data, and inferred data and wherein said apparatus further comprises
instructions for: relating said reference data to a first set of variables; relating said sensed
data to a second set of variables; and inferring a third set of variables from said sensed data.

15 60. The computer program product of claim 48, wherein said probabilistic model
utilizes fast probability methods.

61. The computer program product of claim 60, wherein said fast probability methods
are selected from a group including direct: First Order Reliability Methods, Second Order
20 Reliability Methods, Advanced Mean Value methods, and Mean Value methods.

62. The computer program product of claim 60, wherein said fast probability methods
are selected from a group including response surface: First Order Reliability Methods,
Second Order Reliability Methods, Advanced Mean Value methods, and Mean Value
25 methods.

63. The computer program product of claim 48, wherein said probabilistic model
utilizes simulation techniques.

30 64. The computer program product of claim 63, wherein said simulation techniques are
direct methods selected from a group including: Monte Carlo methods, and importance
sampling methods.

65. The computer program product of claim 63, wherein said simulation techniques are
response surface methods selected from a group including: Monte Carlo methods, and
5 importance sampling methods.

66. The computer program product of claim 49 further comprising a second computer
program product, said second computer program product comprising a second computer
readable storage medium and a second computer program mechanism embedded therein,
10 said second computer program mechanism containing:
instructions for measuring said data;
instructions for storing said data; and
instructions for sending said data to said first computer as said system
information.

15 67. The computer program product of claim 48 further comprising a second computer
program product, said second computer program product comprising a second computer
readable storage medium and a second computer program mechanism embedded therein,
said second computer program mechanism containing:
20 instructions for receiving said prediction; and
instructions for communicating said prediction.

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